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SPACE SHUTTLE ENGINEERING AND OPERATIONS SUPPORT

DESIGN NOTE NO. 1.4-2-7

STAR TRACKER CONSTRAINT VIOLATIONS DIGITAL CAPABILITY DESCRIPTION AND ANALYSIS RESULTS

MISSION PLANNING, MISSION ANALYSIS AND SOFTWARE FORMULATION

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1.0 SUMMARY

Results of star tracker constraint violation analyses performed with the digital computer program Shuttle Attitude and Pointing Time Line Processor (SAPT) are presented in this note. These analysis results are typical of those utilized to provide the information required to update Baseline Reference Mission Attitude and Pointing Time Lines. Descriptions of SAPT modifications implemented to perform these analyses are also presented.

2.0 INTRODUCTION

The purpose of this note is to present results of star tracker constraint violation analyses and to document and discuss the associated modifications to Program SAPT designed to detect star tracker constraint violations. This note, therefore, describes and documents a tool which may be utilized to analyze attitude and pointing time lines, now and in the future, for possible star tracker constraint violations. This capability has been utilized to perform initial analyses which are reflected in the time lines presented in References (1) and (2). This capability and other simulation requirements designed to support attitude profile analyses are discussed briefly in Reference (3).

3.0 DISCUSSION

The orbiter vehicle has three star trackers. Each is sensitive to bright light and cannot be operated within certain regions of the sun or sunlit earth. Attempting to operate any one of the star trackers with its centerline Field of View (FOV) within 30 degrees of the sun or within 20 degrees of the sunlit earth horizon would violate operational constraints imposed on this instrument. Violations may occur while performing Inertial Measurement Unit (IMU) platform alinements or while tracking targets during normal Shuttle activities. This condition in certain cases can be avoided by selecting alternate orbiter attitudes, and a method to detect these violations can be useful in establishing a pre-mission attitude and pointing profile.

Consideration was given to developing a separate program to determine the constraint violations, but it was determined that Program SAPT would be the most convenient tool with which to perform the violation analyses. There are three main reasons why this is the case. First, Program SAPT generates the attitude and pointing time line profiles and contains all of the attitude related information required to establish the necessary attitude transformation relationships. Second, the program can be easily modified, and third, the program employs routines required for certain computations associated with the star tracker constraint violation model.

4.0 RESULTS

Figure 1 depicts the earth pointing constraint detection model implemented in Program SAPT. It assumes the earth is a sphere. Since the earth is assumed to be spherical, the angle, α, between the vehicle to earth-tangent line and vehicle to earth-center line will be constant if the vehicle's altitude remains constant, i.e., if the vehicle's orbit is circular. The earth pointing constraint is violated when the angle between the star tracker FOV centerline and the vehicle to earth centerline, Θ, decreases below the value of $\alpha + 20°$. This is equivalent to the star tracker centerline FOV entering the earth pointing constraint region and, therefore, violating the earth pointing constraint. The sun constraint detection model is implemented in a similar manner. The sun is regarded as a point source, and sun pointing constraints are violated when the star tracker centerline FOV enters within 30 degrees of the sun to vehicle line.

Program SAPT was modified to incorporate this model.

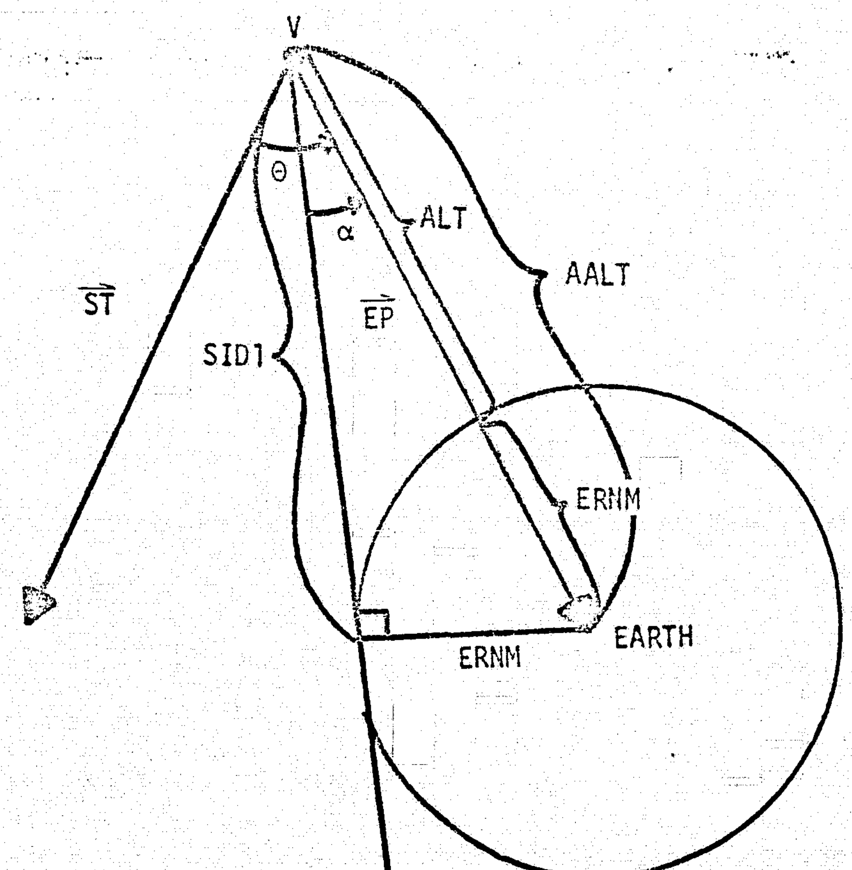

FIGURE 1: MODEL USED IN DETERMINING STAR TRACKER CONSTRAINT VIOLATION ANALYSIS LOGIC *

* All symbols used in model are defined in Appendix A.

The angle between the earth pointing vector in the body coordinate system (as defined in Reference (4)) and the line of sight to the horizon of the earth is computed using equation (1), where ERNM and SID1 are defined in Appendix A.

$$\alpha = \arctan \frac{\text{ERNM}}{\text{SID1}} \quad \ldots \quad (1)$$

For purposes of testing earth pointing constraint violations, α is computed irrespective of lighting conditions of the earth, a consideration that will be given to a later, more sophisticated model. The angle for the testing of sun pointing constraint violations was set to a constant 30°, hence no α computations are required. Expressions to compute theta (Θ), the angle between the earth pointing or sun pointing vectors in the body coordinates, are given by equation (2) for earth pointing and equation (3) for sun pointing.

$$\Theta = \arccos \left[\frac{\vec{ST} \cdot \vec{EP}}{|\vec{ST}| \; |\vec{EP}|} \right] \quad \ldots \quad (2)$$

$$\Theta = \arccos \left[\frac{\vec{ST} \cdot \vec{SP}}{|\vec{ST}| \; |\vec{SP}|} \right] \quad \ldots \quad (3)$$

All symbols used in computing Θ and α, including $\vec{ST}$, $\vec{EP}$ and $\vec{SP}$, are defined in Appendix A, and the basic figure for determining the math model used in program modifications is illustrated in Figure (1).

The star tracker pointing vector, $\vec{ST}$, for star trackers 1, 2, and 3 are computed by taking the transpose of the Body to Star Tracker coordinate transformation matrices obtained from Reference (5) for each Star Tracker, and post multiplying each by the unit vector along the Z coordinate axis $\left(\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}\right)$. The earth pointing and sun pointing vectors used in equations (2) and (3) are computed by SAPT subroutine TARVEC in the earth centered, Aries Mean of 1950, inertial coordinate system described in Reference (4). The vectors are then transformed into the body coordinate system by a call from SAPT to subroutine BPCR (Body Pointing Conversion Routine). Once computed, the dot products of the star tracker pointing vectors and Earth or Sun pointing unit vectors for all pertinent pointing vectors are computed by subroutine UNVEC. Completing all preliminary computations, equations (2) and (3) are employed to compute Θ for each star tracker. Coding of Program SAPT is presented in Appendix B with all modifications indicated by the word "NEW" on the right hand side of the page.

The operation of this logic will be briefly described. A value of 20 degrees is added to the computed α for earth pointing in accordance with the constraints specified in Reference (5). Every Θ corresponding to the combinations of star trackers and earth and sun pointing vectors is then computed. Each Θ is compared against α (+ 20 degrees) for the earth and α (= 30 degrees) for the sun, testing for $\Theta < \alpha$ ($\alpha + 20°$ for the earth). If such tests are successful, i.e. $\Theta < \alpha$, a special code as defined in Reference (6) is output through modifications to SAPT output logic, indicating which constraint had been violated — Earth Pointing or Sun Pointing Constraints — and which Star Trackers are in violation of that particular constraint. If the event being processed is not a platform alinement, computations and tests are not considered, and most computation logic is skipped.

Modifications for star tracker constraint violations analysis were used in the checkout of platform alinements being considered for certain inertial hold attitudes defined in the Preliminary Baseline Reference Mission (BRM) 2, Sortie Option 1 Attitude and Pointing Time Lines. Results indicated that nearly 90% of the alinements were performed with constraint violations, as illustrated in Reference (6). Sortie Options 2 and 3 of BRM 2 as well as BRM 1 showed similar results. Sortie Option 2 of BRM 2 is illustrated in Appendix C which shows that 8 out of 9 platform alinements violate star tracker pointing constraints when holding the prior inertial attitude.

Since extensive violations occurred in the inertial attitude just prior to a platform alinement, a maneuver to the LVLH attitude at 0,0,0 was then assumed, just prior to each Platform Alinement, and checkout attitude and pointing time lines were generated. Results showed no violations occurring for any Sortie Option of Mission 2, but due to the relatively low altitude for Mission 1, platform alinements performed in the inertial hold mode at an initial LVLH attitude of 0,0,0 always violated the earth pointing constraint for star tracker 3. (Appendix (D))

In updating BRM 1 and 2 time lines, the same violations were assumed to hold since new trajectories indicated no change in altitude. Checkout results indicated this to be the case. For updates to BRM 1, therefore, a slight Roll of +5° was employed to assume an LVLH attitude at 0,0,5, with checkout results indicating that the selected attitude was sufficient to prevent further violation of constraints. A study of results using Star Tracker constraint violation detection logic revealed that updated Preliminary BRM 1 and 2 could be generated with platform alinements in LVLH attitudes at 0,0,5 and 0,0,0 respectively without violating any Star Tracker constraints. Results of updated time line generation for BRM 1 and 2 are illustrated in References (1) and (2).

5.0 CONCLUSION

The analysis results presented in Appendices C and D of this note are typical of those performed on preliminary Baseline Reference Mission Attitude and Pointing Time Lines to insure that no star tracker near earth or near sun pointing constraints were violated during IMU platform alinements.

The documented description of Star Tracker constraint violation modifications to program SAPT and descriptions of results using these modifications, as presented in this note,initially provides an adequate source of information. Program SAPT can be used to efficiently detect Star Tracker constraint violations and employ possible methods to insure avoidance of these violations. It is planned to upgrade the model used to detect star tracker constraint violations to include an ellipsoidal earth model, earth occultation,earth lighting, and vehicle attitude dispersions. Capabilities such as these, to analyse attitude profiles, will continue to be developed, and analyses utilizing these capabilities will be performed to refine attitude and pointing profiles based on known attitude and pointing related constraints.

6.0 REFERENCES

1. SSEOS 1.4-MIB-16, "Preliminary Baseline Reference Mission 1 Attitude and Pointing Time Lines", McDonnell Douglas Technical Services Company, Inc., dated 17 January 1975.
2. SSOES 1.4-MIB-12, "Preliminary Baseline Reference Mission 2 Attitude and Pointing Time Lines", McDonnell Douglas Technical Services Company, Inc., dated 8 January 1975.
3. SSEOS Design Note No. 1.4-2-6, "Attitude and Pointing Simulation Requirements and Program Updates", dated 24 December 1974.
4. JSC-09084, NASA TM X-58153, "Coordinate Systems for the Space Shuttle Program", dated October 1974.
5. SSEOS Design Note No. 1.4-2-4, "Orbiter Star Tracker Orientations, Operational Requirements and Coordinate Transformations", dated 24 October 1974.
6. SSEOS TM-1.4-MIB-9, "Detection of Star Tracker Constraint Violations", dated 16 December 1974.

APPENDIX A: LIST OF SYMBOLS USED IN STAR TRACKER CONSTRAINT VIOLATION LOGIC

(1) V - Reference Vehicle

(2) ALT - Vehicle Altitude in Nautical Miles Referenced from Surface of the Earth - Computed in Subroutine NADIR and Returned to Program SAPT

(3) ERNM - Earth Radius Expresed in Nautical Miles - Placed into SAPT by use of the DATA Statement

(4) AALT - Total Distance from the Center to the Earth to the Reference Vehicle in Nautical Miles -
AALT = ALT + ERNM

(5) SID1 - Distance from Reference Vehicle to Tangent of Line of Sight to Horizon and the Earth in Nautical Miles -

$$SID1 = \sqrt{(AALT)^2 - (ERNM)^2}$$

(6) $\overrightarrow{EP}$ - Earth Pointing Vector Expressed in Body Coordinates

(7) $\overrightarrow{SP}$ - Sun Pointing Vector Expressed in Body Coordinates

(8) $\overrightarrow{ST}$ - Star Tracker Pointing Vectors for Star Trackers 1, 2, and 3, Expressed in Body Coordinates

(9) α - Angle Between Earth Pointing Vector and Line of Sight to the Horizon of the Earth Expressed in Degrees -
α = [ARCTAN (ERNM/SID1)] X 57.29577951

(10) Θ - Angle Between Earth Pointing Vector or Sun Pointing Vector and Star Tracker Pointing Vectors for each Star Tracker, Expressed in Body Coordinates -

$$\Theta_1 = \left[\text{ARCCOS}\left(\frac{\overrightarrow{ST} \cdot \overrightarrow{EP}}{|\overrightarrow{ST}|\ |\overrightarrow{EP}|}\right)\right] \times 57.29577951$$

$$\Theta_2 = \left[\text{ARCCOS}\left(\frac{\overrightarrow{ST} \cdot \overrightarrow{SP}}{|\overrightarrow{ST}|\ |\overrightarrow{SP}|}\right)\right] \times 57.29577951$$

CODING OF PROGRAM SAPT WITHOUT SUBROUTINES

```
00100   CDI          **** PROGRAM SAPT ****
00100   CDI   THE SHUTTLE ATTITUDE AND POINTING TIMELINE PROCESSOR (SAPT) IS THE
00100   CDI    BASIC ATTITUDE AND POINTING TIMELINE GENERATION PROGRAM FOR
00100   CDI    SHUTTLE. SAPT CAN GENERATE ATTITUDE AND POINTING TIMELINE TABLES
00100   CDI    FOR DOCUMENTATION AND AT THE SAME TIME ALSO GENERATE ATTITUDE
00100   CDI    TAPES FOR SUBSYSTEM EVALUATIONS. THE BASIC INPUT IS IN THE FORM
00100   CDI    OF ATTITUDE AND POINTING DESCRIPTOR CARDS DEFINING THE NAME OF
00100   CDI    THE EVENT, THE EVENT TIME, AND DESCRIPTORS DEFINING THE ATTITUDE
00100   CDI    AND POINTING REQUIREMENTS FOR THE EVENT. THE PROGRAM REQUIRES
00100   CDI    A TRAJECTORY TAPE MOUNTED ON UNIT F, AN EPHEMERIS TAPE MOUNTED ON
00100   CDI    UNIT K, AND A PCF TAPE INCLUDING SAPT. IF AN ATTITUDE TAPE IS ALSO
00100   CDI    TO BE GENERATED, A SAVE TAPE MUST BE MOUNTED ON THE TAPE UNIT
00100   CDI    DEFINED BY ITAPE. THE FIRST INPUT CARD AFTER THE XQT CARD MUST BE
00100   CDI    A BASE CARD GIVING THE BASE DATE TO MEASURE G.E.T. FROM AND THE
00100   CDI    TAPE UNIT AND PRINT INTERVAL IF A ATTITUDE TAPE IS TO BE GENERATED
00100   CDI    THERE IS ALSO AN INPUT FLAG WHICH DEFINES A TAPE UNIT TO WRITE A
00100   CDI    DESCRIPTOR TIMELINE. AFTER THE BASE CARD, THE ATTITUDE AND POINT-
00100   CDI    ING DESCRIPTOR CARDS FOLLOW. THERE MAY BE UP TO 4 CARDS REQUIRED
00100   CDI    TO DEFINE EACH EVENT. THE FIRST CARD IN EACH EVENT SET IS THE
00100   CDI    EVENT NAME CARD. UP TO 4 LINES OF EVENT DESCRIPTION CAN BE DEFINED
00100   CDI    WITH 18 CHARACTERS TO EACH LINE. THE NEXT CARD IS THE ATTITUDE
00100   CDI    REQUIREMENTS CARD GIVING THE EVENT TIME AND ATTITUDE ONLY REQUIR-
00100   CDI    MENTS. IF THERE ARE NO POINTING REQUIREMENTS, THIS IS THE LAST
00100   CDI    CARD OF THE SET. IF THERE ARE POINTING REQUIREMENTS, 1 OR 2 MORE
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00100   CD1   CARDS ARE REQUIRED DEPENDING ON THE NUMBER OF POINTING REQUIRE-
00100   CD1   MENTS. EVENT SETS SHOULD BE STACKED IN CHRONOLOGICAL ORDER. THE
00100   CD1   LAST CARD OF THE DECK IS LABELED 'END CARD' STARTING IN CC 1.
00100   CD1   THE INPUT PARAMETER DEFINITIONS FOR THE BASE CARD ARE GIVEN BELOW.
00100   CD1   THE INPUT DEFINITIONS FOR THE EVENT SETS ARE GIVEN IN SUBROUTINE
00100   CD1   'CARDIN'
00100   CD2  BASE CARD DEFINITIONS -
00100   CD2   NBASYR,NBASMT,NBASDY,NBASHR,NBASMN,BASSEC
00100   CD2            - BASE G.M.T. THAT G.E.T. IS MEASURED FROM (NOMINALLY THE
00100   CD2              LAUNCH G.M.T.
00100   CD2   ITAPE   - UNIT ON WHICH THE COMMON FORMAT ATTITUDE TAPE IS TO BE
00100   CD2              WRITTEN. IF ZERO, NO TAPE IS REQUIRED.
00100   CD2   GMTINT - TIME INCREMENT BETWEEN PRINT POINTS DESIRED FOR THE
00100   CD2              COMMON FORMAT TAPE. (MINUTES)
00100   CD2   IUREAD - UNIT ON WHICH THE INPUT ATTITUDE DESCRIPTOR FILE WILL BE
00100   CD2              MOUNTED. IF ZERO, ALL INPUT WILL BE MANUAL.
00100   CD2   IUWRT   - UNIT ON WHICH THE REVISED ATTITUDE DESCRIPTOR FILE IS TO
00100   CD2              BE WRITTEN. IF ZERO, NO TAPE IS TO BE WRITTEN.
00100   CD2   IHRST,MINST,SECST
00100   CD2            - GET TO START ATTITUDE TIMELINE IF A DESCRIPTOR FILE HAS
00100   CD2              BEEN PROVIDED. IF NOT INPUT, THE START OF THE DESCRIPTOR
00100   CD2              FILE, OR THE FIRST MANUAL INPUT, WHICHEVER IS EARLIER,
00100   CD2              WILL BE USED.
00100   CD2   IHREND,MINEND,SECEND
00100   CD2            - GET TO END ATTITUDE TIMELINE IF A DESCRIPTOR FILE HAS
00100   CD2              BEEN PROVIDED. IF NOT INPUT, THE END OF THE DESCRIPTOR
00100   CD2              FILE, OR THE LAST MANUAL INPUT, WHICHEVER IS LATER,
00100   CD2              WILL BE USED.
00100   C
00101         INTEGER ATTSYS,ALIGN
00103         REAL IANG1,IANG2,IANG12,IANG22
00104         DOUBLE PRECISION BASEJD,BASTIM,TGET,GMT,GMTP
00105         DOUBLE PRECISION GMTNXT,TSMCAL,TNEXT,TIMTAP
00106         DOUBLE PRECISION XIMUDP,YIMUDP,ZIMUDP,RKMDP(3),VKMDP(3),DV(3)
00107         DOUBLE PRECISION GET
00110         DOUBLE PRECISION RSUNDP(3)
00111         REAL LIFTKG,ISPSEC
00112         REAL KX,KY,KZ,NUZ,MINTIM
00113         DIMENSION DUMMAT(15),R(3),V(3),RSUN(3),VSUN(3),RMOON(3),VMOON(3)
00114         DIMENSION TARGET(3),TDVEC(3),ATTLV(3,3),ATTI(3,3),SUNVEC(3),
00114        * PB(3),COEVEC(3),ATTECI(3,3)
00115         DIMENSION RKM(3),VKM(3),RKMU(3),RSUNU(3)
00116         DIMENSION ATTSR(3,3)
00117         DIMENSION SPARE(14),RSUNKM(3)
00120         DIMENSION ST12(3),ST3(3),SOSO(3),HOMO(3)                      *NEW
00121         DIMENSION SMAG1(3),SMAG2(3),SMAG3(3),SMAG4(3)                 *NEW
00122         COMMON/BASDT/ BASEJD,BASTIM,NBASYR,NBASMT,NBASDY,NBASHR,NBASMN,
00122        * BASSEC
00123         COMMON/ATPCOM/ GMTP,ATTP(3,3)
00124         COMMON/IERRCM/ IERR
00125         COMMON / VEHLB / KX,KY,KZ,NUZ,BETA,RASUN,DECSUN,RAMOON,DECMON
00126         COMMON/SMCALL/ TSMCAL,RSUN,VSUN,RMOON,VMOON
00127         COMMON/CARDS/IHR,MN,SECS,ATTSYS,IMUNUM,IVMS,ANG1,ANG2,ANG3,
00127        * IHOLD,XRATE,YRATE,ZRATE,IPTFLG,ALIGN,INSTID,IANG1,IANG2,
00127        * ITYPE1,IDEF1,VAR1,VAR2,VAR3,ITARG1,VAR4,IDIN2,IANG12,IANG22,
00127        * ITYPE2,IDEF2,VAR12,VAR22,VAR32,ITARG2,VAR42
00130         COMMON/TVCOM/ ITARG,ALPHAT,BETAT,WVEC(3),ALPHAC,BETAC,AT,
00130        * TLON,TLAT,ITYPE,IDEF
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00131          COMMON/EVNCOM/NEVENT(12),NAMTAR
00132          COMMON / REVST / REV
00132     C    REV = REV NUMBER OF VEHICLE FROM START OF MISSION
00133          COMMUN /TRJCNV /A,E,DINC,ARGPER,ASCNOD,AM,OMEAN,TRUEAN,PERIOD
00134          DATA RTD/57.2957795/,SECPHR/3600.0/
00137          DATA DUMMAT / 15 * 0.0 /,MINTIM / -1.0 /
00142          DATA ITAPE / 15 /
00144          DATA NBLANK/6H      /,MAXLIN/56/,NUMLIN/56/
00150          DATA NCARD / 6H      /
00150     C    EGRAVC - GRAVITATIONAL CONSTANT OF THE EARTH ( KM**3 / SEC**2 )
00152          DATA EGRAVC / 398.60119999 /
00152     C    DV - SENSED VELOCITY CHANGE OVER TIME INTERVAL BETWEEN PRESENT
00152     C         AND PREVIOUS RECORD
00154          DATA DV / 0.000,0.000,0.000  /
00156          DATA SPARE / 14 * 0.0 /
00160          DATA NUMENT/1/
00160     C                                                                  *NEW
00160     C-----STORE VALUES FOR STAR TRACKER POINTING VECTORS               *NEW
00160     C     IN BODY COORDINATES, ANGLE ALPHA FOR SUN POINTING            *NEW
00160     C     CONSTRAINTS,EARTH RADIUS IN NAUTICAL MILES,                  *NEW
00160     C     AND CODES FOR VIOLATION OUTPUT------                         *NEW
00160     C                                                                  *NEW
00162          DATA ST12/0.0,0.0,-1.0/,ST3/-.25881904,-.96592583,0.0/         *NEW
00165          DATA SALPHA/30.0/                                              *NEW
00167          DATA ERNM/3443.931/                                            *NEW
00171          DATA IA/1HA/,IB/1HB/,IC/1HC/,ID/1HD/,IE/1HE/,IQ/1H /,IG/1HG/,  *NEW
00171         *IH/1HH/,INAME/6HPLATFO/                                        *NEW
00203          PRTFLG = 0.0
00204          LIFTKG = 0.0
00205          DYNPR = 0.0
00206          DRAGKG = 0.0
00207          WGTKG = 0.0
00210          THRKG = 0.0
00211          ISPSEC = 0.0
00212          CALL INTMSG(0,0,0)                                             *NEW
00212     C  BASE CARD VALUES AND FORMAT FOLLOW                               ***1
00212     C
00213          READ(5,910) NBASYR,NBASMT,NBASDY,NBASHR,NBASMN,BASSEC,
00213         * ITAPE,GMTINT,IUREAD,IUWRT,IHRST,MINST,SECST,IHREND,MINEND,SECEND
00213         *,IASTP
00236      910 FORMAT(1X,I4,4(1X,I2),1X,F5.2,1X,I2,1X,F6.0,2(1X,I2),
00236         *  2(1X,I4,1X,I2,1X,F5.2),12X,I1)
00236     C
00237          WRITE(6,900)
00241      900 FORMAT(1H1)
00242          CALL DATEC
00243          GETST = IHRST + MINST/60.0  + SECST/3600.0
00244          GETEND = IHREND + MINEND/60.0 + SECEND/3600.0
00245          IF(GETEND .LE. GETST) GETEND = 200.0
00247          CALL INPROC(IUREAD,GETST,GETEND,NUMENT)
00250      100 CONTINUE
00250     C  THE CALL TO GETDES OBTAINS THE FIRST EVENT SET
00250     C
00251          CALL GETDES(IUREAD,ISTOP)
00251     C
00252          CALL CRDFIL(1)
00253          IF(ISTOP .GT. 0) GO TO 350
00255          IF(IERR .GT. 0) STOP
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00257        120 CONTINUE
00260            JPCARD = 1
00261            TGET = IHR + MN/60 + SECS/3600
00262            GMT = TGET + BASTIM
00263        150 CONTINUE
00264            CALL TIMEC(GMT,IDAYN,IHRN,MINN,SECN)
00265            TIMTAP = GMT - BASTIM
00266            CALL TIMEC (TIMTAP,IDT,IHT,IMT,ST)
00267            IHT = IDT*24 + IHT
00270            TTAPE = SNGL(TIMTAP)
00271            IF(IHRN .GT. 2) .AND. (IDAYN - IDCALL) .EQ. 1) IDCALL = IDCALL-1
00273            IF((IDAYN - IDCALL) .GE. 0 .AND. (IDAYN - IDCALL) .LT.2) GO TO 200
00275            IDCALL = IDAYN
00276            IF(IHRN .LT. 2) IDCALL = IDAYN - 1
00300            CALL INITAL(IDCALL,ISTOP)
00301            IF(ISTOP .GT. 0) STOP
00303        200 CONTINUE
00304            IF(ALIGN .NE. 1) GO TO 220
00306            CALL CRDFIL(2)
00307            CALL ATTDEF(GMT,ATTP)
00310            GMTP = GMT
00311            CALL CRDFIL(1)
00312        220 CONTINUE
00313            IF (ATTSYS .EQ. NBLANK) IBLANK = 1
00315            IF(ATTSYS .EQ. NBLANK) CALL CRDFIL(2)
00317            CALL ATTDEF(GMT,ATTECI)
00320            CALL CRDFIL(1)
00321            IF(ATTSYS .NE. NBLANK) GO TO 225
00323            DO 223 I=1,3
00326            DO 223 J=1,3
00331            ATTI(I,J) = ATTECI(I,J)
00332        223 CONTINUE
00335            CALL EULER(ATTI,IVMS,ANG1,ANG2,ANG3,ATTECI)
00336        225 CONTINUE
00337            CALL NADIR(GMT,SCLON,GDLAT,ALT)
00337      C                                                                 *NEW
00337      C-----COMPUTE ANGLE  ALPHA(ANGLE BETWEEN VEHICLE TO COE VECTOR AND    *NEW
00337      C     STAR TRACKER POINTING VECTOR) FOR EARTH POINTING CONSTRAINTS,   *NEW
00337      C     AND ADD 20 DEGREES TO ALPHA TO COMPUTE FINAL ALPHA FOR          *NEW
00337      C     STAR TRACKER EARTH POINTING CONSTRAINT VIOLATIONS CHECKOUT------- *NEW
00337      C                                                                 *NEW
00340            AALT=ERNM+ALT                                                   *NEW
00341            TRIA1=(AALT**2)-(ERNM**2)                                       *NEW
00342            SIDI=SQRT(TRIA1)                                                *NEW
00343            EALPHA=ATAN2(ERNM,SIDI)                                         *NEW
00344            EALPHA=EALPHA*RTD                                               *NEW
00345            EALPHA=EALPHA+20.0                                              *NEW
00346            WRITE(6,137)EALPHA                                              *NEW
00351      137   FORMAT(1X,F10.5)                                                *NEW
00352            IF(IPTFLG .EQ. 0) GO TO 250
00354            CALL FILTVC(1)
00355            IF(ATTSYS.EQ.NBLANK) CALL CRDFIL(2)
00357            CALL TARVEC(GMT,NEWVEL,TARGET,TDVEC)
00360            CALL BPCR(1,ATTECI,TARGET,PB)
00361            CALL YWPTCH(2,YAWTAR,PTCTAR,PB)
00362        250 CONTINUE
00363            ITYPE =1
00364            IDEF = 8
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      CALL TARVEC(GMT,NEWVEL,SUNVEC,TDVEC)
      CALL BPCR(1,ATTECI,SUNVEC,PB)
C                                                                 *NEW
C-----SAVE SUN POINTING VECTOR IN BODY COORDINATES------          *NEW
C                                                                 *NEW
      DO19I=1,3                                                   *NEW
      SOSO(I)=PB(I)                                               *NEW
   19 CONTINUE                                                    *NEW
      CALL YWPTCH(2,YAWSUN,PTCSUN,PB)
      ITYPE = 1
      IDEF = 1
      CALL TARVEC(GMT,NEWVEL,COEVEC,TDVEC)
      CALL BPCR(1,ATTECI,COEVEC,PB)
C                                                                 *NEW
C-----SAVE EARTH POINTING VECTOR IN BODY COORDINATES FOR LATER USE------ *NEW
C                                                                 *NEW
      DO13J=1,3                                                   *NEW
      HOMO(J)=PB(J)                                               *NEW
   13 CONTINUE                                                    *NEW
      CALL YWPTCH(2,YAWCOE,PTCCOE,PB)
      CALL ACP(1,2,2,4,1,3,3,IMUNUM,IMUNUM,GMT,GMT,ATTECI,TDVEC,
     * OMG,0.0,0.0,0.0,YRATE,ZRATE,XRATE,ATTLV,YOFF,ZOFF,XOFF)
      ZLVLH = ZOFF*RTD
      YLVLH = YOFF*RTD
      XLVLH = XOFF*RTD
      IF(ZLVLH .LT. -0.05) ZLVLH = 360.0 + ZLVLH
      IF(YLVLH .LT. -0.05) YLVLH = 360.0 + YLVLH
      IF(XLVLH .LT. -0.05) XLVLH = 360.0 + XLVLH
      IF(IHOLD .NE. 1) GO TO 260
      CALL ZLVDOT(7,XLVLH,YLVLH,ZLVLH,XRATE,YRATE,ZRATE)
      XRATE = XRATE*(SECPHR/RTD)
      YRATE = YRATE*(SECPHR/RTD)
      ZRATE = ZRATE*(SECPHR/RTD)
  260 CONTINUE
      IF(IMUNUM .EQ. 0) IMUNUM=1
      M=3
      IF(IASTP.EQ.1) M=2
      CALL ACP(1,2,2,4,3,3,M,IMUNUM,IMUNUM,GMT,GMT,ATTECI,TDVEC,
     * OMG,0.0,0.0,0.0,YRATE,ZRATE,XRATE,ATTI,YOFF,ZOFF,XOFF)
      ZIMU = ZOFF*RTD
      YIMU = YOFF*RTD
      XIMU = XOFF*RTD
      IF(ZIMU .LT. -0.05) ZIMU = 360.0 + ZIMU
      IF(YIMU .LT. -0.05) YIMU = 360.0 + YIMU
      IF(XIMU .LT. -0.05) XIMU = 360.0 + XIMU
      YAWTAR = YAWTAR*RTD
      PTCTAR = PTCTAR*RTD
      YAWSUN = YAWSUN*RTD
      PTCSUN = PTCSUN*RTD
      YAWCOE = YAWCOE*RTD
      PTCCOE = PTCCOE*RTD
      IF(SCLON .GT. 180.0) SCLON = SCLON - 360.0
      NUMCOM = 1
      DO 280 I=2,4
      DO 280 J=1,3
      IJ =(I-1)*3 + J
      IF(NEVENT(IJ) .NE. NBLANK) NUMCOM = I
  280 CONTINUE
```

```
00476             CALL TRAJC1 (GMT,R,V,JERR)
00477             IF (JERR .GT. 0) STOP
00501             RMAG = VECMG(R)
00502             IF (ITAPE .EQ. 0) GO TO 288
00504             RECFLG = 1.0
00504       C     RECFLG- LAST RECORD IN FILE FLAG, IF LESS THAN 0.0 THIS IMPLIES
00504       C             LAST RECORD IN FILE
00504       C     PRTFLG- FLAG INDICATING TYPE OF PRINT POINT
00505             CALL GMTCAL (GMT,NBASYR,YEAR,GMONTH,GDAY,GHR,GMIN,GSEC )
00505       C     SUBROUTINE GMTCAL WILL COMPUTE GREENWICH MEAN TIME IN YEAR,
00505       C     MONTH,DAY,HOUR,MINUTES, AND SECONDS FROM THE BEGINNING OF THE
00505       C     BASE YEAR (NBASYR).
00506             GET = GMT - BASTIM
00506       C     GET - TIME IN HOURS FROM LAUNCH
00507             DO 281 J=1,3
00512             RKM(J) = R(J) * 6378.16
00512       C     RKM - VEHICLE RADIUS VECTOR (ECI) IN KM
00513             VKM(J) = V(J) * (6378.16 / 3600.0 )
00513       C     VKM - VEHICLE VELOCITY VECTOR (ECI) IN KM/SEC
00514             RSUNDP(J) = DBLE(RSUN(J)) * 6378.16D00
00515             RSUNKM(J) = SNGL(RSUNDP(J) )
00515       C     RSUNKM - SUN VECTOR IN KM (ECI)
00516         281 CONTINUE
00520             DO 285 I=1,3
00523             RKMDP(I) = DBLE (RKM(I) )
00523       C     RKMDP -  VEHICLE RADIUS VECTOR (DOUBLE PRECISION )
00524             VKMDP(I) = DBLE (VKM(I) )
00524       C     VKMDP -  VEHICLE VELOCITY VECTOR (DOUBLE PRECISION)
00525         285 CONTINUE
00527             XIMUDP = DBLE (XIMU) / 57.2957795D0
00530             YIMUDP = DBLE (YIMU) / 57.2957795D0
00531             ZIMUDP = DBLE (ZIMU) / 57.2957795D0
00531       C     YIMUDP,ZIMUDP,XIMUDP- PITCH, YAW, AND ROLL GIMBAL ANGLES (RADIANS)
00531       C                         WITH RESPECT TO INPUT REFSMMAT
00532             RMAGKM = VECMG (RKM)
00532       C     RMAGKM - VEHICLE GEOCENTRIC RADIUS (KM)
00533             CALL UNVEC (RKM,RKMU)
00533       C     RKMU - VEHICLE UNIT  RADIUS  VECTOR (ECI)
00534             DECGCN = ASIN  (RKMU(3))
00534       C     DECGCN - VEHICLE GEOCENTRIC DECLINATION (RADIANS)
00535             RASGCN = ATAN2 (RKMU(2),RKMU(1) )
00535       C     RASGCN - VEHICLE GEOCENTRIC RIGHT ASCENSION (RADIANS)
00536             VMAGKM = VECMG(VKM)
00536       C     VMAGKM - VEHICLE INERTIAL VELOCITY VECTOR MAGNITUDE (KM/SEC)
00537             VALTKM = ALT * (6378.16 / 3443.9308855)
00537       C     VALTKM - VEHICLE ALTITUDE ABOVE OBLATE EARTH (KM)
00540             VEHGDL = GDLAT / RTD
00540       C     VEHGDL - VEHICLE GEODETIC LATITUDE (RADIANS)
00541             VEHLON = SCLON / RTD
00541       C     VEHLON - VEHICLE LONGITUDE (RADIANS)
00542             CALL FPAZ  (GMT,GAMI,PSII,VELREL,GAMREL,PSIREL,GRAS )
00542       C     GAMI - INERTIAL FLIGHT PATH ANGLE (RADIANS)
00542       C     PSII - INERTIAL AZIMUTH (RADIANS)
00542       C     VELREL - RELATIVE VELOCITY VECTOR MAGNITUDE (KM/SEC)
00542       C     GAMREL - RELATIVE FLIGHT PATH ANGLE (RADIANS)
00542       C     PSIREL - RELATIVE AZIMUTH (RADIANS)
00542       C     GRAS - RIGHT ASCENSION OF GREENWICH (RADIANS)
00543             AKM = A * ( 1.0 / 3280.833 )
```

```
00543   C     AKM - SEMIMAJOR AXIS (KM)
00543   C     E - ECCENTRICITY
00544         RADINC = DINC / RTD
00544   C     RADINC - INCLINATION TO ORBITAL PLANE (RADIANS)
00545         ASCNR = ASCNOD / RTD
00545   C     ASCNR - RIGHT ASCENSION OF ASCENDING NODE (RADIANS)
00546         ARGPR = ARGPER / RTD
00546   C     ARGPR - ARGUMENT OF PERIGEE (RADIANS)
00546   C     TRUEAN - TRUE ANOMALY (RADIANS)
00546   C     PERIOD - ORBITAL PERIOD (SECONDS)
00546   C     SHADOW = 1.0  VEHICLE IN DIRECT SUNLIGHT
00546   C            =-1.0  VEHICLE IN DARKNESS
00547         SHADOW = 1.0
00550         CALL UNVEC (RSUN,RSUNU)
00551         COSANG = DOT (RKMU,RSUNU)
00552         IF ( ABS(COSANG) .GE. 1.0) COSANG = SIGN (1.0,COSANG)
00554         IF ( ACOS(COSANG) .GE. ( 180.0 - ASIN(1.0/ RMAG)) ) SHADOW = -1.0
00554   C     ATTECI - DIRECTION COSINES OF THE X,Y, AND Z BODY AXES WITH
00554   C              RESPECT TO THE ECI COORDINATE SYSTEM
00556         CALL ACP (1,2,2,4,5,3,3,IMUNUM,IMUNUM,GHT,GMT,ATTECI,TDVEC,
00556        * OMG,0.0,0.0,0.0,0.0,0.0,0.0,0.0,ATTSR,ALSR,BTSR,GMSR )
00556   C     ALSR - PITCH FROM SOLAR REFERENCE SYSTEM (ZYX EULER)
00556   C     BTSR - YAW FROM SOLAR REFERENCE SYSTEM (ZYX EULER)
00556   C     GMSR - ROLL FROM SOLAR REFERENCE SYSTEM (ZYX EULER)
00557         YLVLHR = YLVLH / RTD
00557   C     YLVLHR - VEHICLE PITCH ANGLE FROM LOCAL VERTICAL IN RADIANS.
00557   C              (ZYX EULER) YAW-PITCH SEQUENCE
00560         ZLVLHR = ZLVLH / RTD
00560   C     ZLVLHR - VEHICLE  YAW  ANGLE FROM LOCAL VERTICAL IN RADIANS.
00560   C              (ZYX EULER) YAW-PITCH SEQUENCE
00561         XLVLHR = XLVLH / RTD
00561   C     XLVLHR - VEHICLE  ROLL ANGLE FROM LOCAL VERTICAL IN RADIANS.
00561   C              (ZYX EULER) YAW-PITCH SEQUENCE
00562         PTSUNR = PTCSUN / RTD
00562   C     PTSUNR - LOOK ANGLE THETA FROM VEHICLE TO SUN (YAW-PITCH SEQUENCE)
00563         YWSUNR = YAWSUN / RTD
00563   C     YWSUNR - LOOK ANGLE PHI FROM VEHICLE TO SUN (YAW-PITCH SEQUENCE)
00564         PTCOER = PTCCOE / RTD
00564   C     PTCOER - LOOK ANGLE THETA FROM VEHICLE TO CENTER OF EARTH.
00565         YWCOER = YAWCOE / RTD
00565   C     YWCOER - LOOK ANGLE PHI FROM VEHICLE TO CENTER OF EARTH.
00565   C     SPARE - MATRIX FOR SPARE WORDS TO BE RESERVED FOR FUTURE USE
00565   C
00565   C  THE ATTITUDE TAPE RECORDS ARE WRITTEN BELOW
00565   C
00566         WRITE (ITAPE)                     RECFLG,PRTFLG,YEAR,GMONTH,GDAY,
00566        *GHR,GMIN,GSEC,GET,(RKMDP(I),I=1,3),(VKMDP(I),I=1,3),(DV(I),I=1,3),
00566        * YIMUDP,ZIMUDP,XIMUDP,RMAGKM,DECGCN,RASGCN,VMAGKM,GAMI,PSII,
00566        * VALTKM,VEHGDL,VEHLON,VELREL,GAMREL,PSIREL,GRAS,REV,AKM,E,RADINC,
00566        * ASCNR,ARGPR,TRUEAN,PERIOD,DYNPR,DRAGKG,LIFTKG,WGTKG,THRKG,ISPSEC,
00566        * EGRAVC,SHADOW,(ATTECI(1,J),J=1,3),(ATTECI(2,J),J=1,3),
00566        * (ATTECI(3,J),J=1,3),YLVLHR,ZLVLHR,XLVLHR,ALSR,BTSR,GMSR,PTSUNR,
00566        * YWSUNR,PTCOER,YWCOER,(RSUNKM(I),I=1,3),(SPARE(I),I=1,14)
00713     288 CONTINUE
00713   C
00714         IF (JPCARD .EQ. 1) GO TO 290
00716         NUMCOM = 1
00717     290 CONTINUE
```

ORIGINAL PAGE IS
OF POOR QUALITY

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      IF(INUMLIN + NUMCOM) .LE. MAXLIN) GO TO 300
      WRITE(6,950)
  950 FORMAT(1H1,43X,'SHUTTLE ATTITUDE AND POINTING TIME LINE'//
     * 90X,'LOOK ANGLES   LOOK ANGLES    LOOK ANGLES'/
     * 34X,'VEHICLE POSITION    LVLH ATTITUDE',7X,'ECI ATTITUDE',6X,
     * 'TO SUN',6X,'TO EARTH',8X,'TO TARGET'/5X,'GET',
     * 25X,'ALT',3X,'LAT',4X,'LON',4X,'YAW  PITCH  ROLL   YAW  PITCH  ',
     * 'ROLL   YAW  PITCH   YAW  PITCH  TARG  YAW  PITCH'/
     * 1X,'HRS MN SECS',7X,'EVENT',9X,'N MI  DEG',4X,'DEG    DEG   DEG',
     * 3X,'DEG    DEG   DEG    DEG    DEG    DEG    DEG    ID',
     * 3X,'DEG   DEG'/)
      NUMLIN = 7
  300 CONTINUE
C  THE ATTITUDE AND POINTING TABLE IS WRITTEN BELOW.
C
C                                                                 *NEW
C-----COMPUTE ANGLE THETA BETWEEN STAR TRACKER POINTING VECTORS FOR  *NEW
C     STAR TRACKERS 1,2, AND 3                                    *NEW
C     AND SUN AND EARTH POINTING VECTORS, CHECK FOR EACH THETA    *NEW
C     LESS THAN ALPHA=30 DEGREES FOR SUN, AND THETA LESS          *NEW
C     THAN EARTH ALPHA + 20 DEG. FOR EARTH, AND OUTPUT            *NEW
C     ANY VIOLATION ENCOUNTERED ACCORDING TO SPECIAL CODE         *NEW
C     IF EVENT IS NOT PLATFORM ALINEMENT, THEN COMPUTATIONS       *NEW
C     ARE NOT NECESSARY, AND LOGIC IS SKIPPED------               *NEW
C                                                                 *NEW
      IF(NEVENT(1).NE.INAME) GO TO 3179                           *NEW
      CALL UNVEC(ST12,SMAG1)                                      *NEW
      CALL UNVEC(ST3,SMAG2)                                       *NEW
      CALL UNVEC(SOSO,SMAG3)                                      *NEW
      CALL UNVEC(HOMO,SMAG4)                                      *NEW
      DOTP1=DOT(SMAG1,SMAG3)                                      *NEW
      DOTP2=DOT(SMAG2,SMAG3)                                      *NEW
      DOTP3=DOT(SMAG1,SMAG4)                                      *NEW
      DOTP4=DOT(SMAG2,SMAG4)                                      *NEW
      ATHET1=ACOS(DOTP1)                                          *NEW
      ATHET1=ATHET1*RTD                                           *NEW
      ATHET2=ACOS(DOTP2)                                          *NEW
      ATHET2=ATHET2*RTD                                           *NEW
      ATHET3=ACOS(DOTP3)                                          *NEW
      ATHET3=ATHET3*RTD                                           *NEW
      ATHET4=ACOS(DOTP4)                                          *NEW
      ATHET4=ATHET4*RTD                                           *NEW
      IZ=IQ                                                       *NEW
      IF(ATHET1.LT.SALPHA.AND.ATHET4.LT.EALPHA) GO TO 23          *NEW
      IF(ATHET1.LT.SALPHA) IZ=IA                                  *NEW
      IF(ATHET4.LT.EALPHA) IZ=IB                                  *NEW
      GO TO 24                                                    *NEW
   23 IZ=IH                                                       *NEW
      GO TO 28                                                    *NEW
   24 IF(ATHET3.LT.EALPHA.AND.ATHET2.LT.SALPHA) GO TO 25          *NEW
      IF(ATHET3.LT.EALPHA) IZ=IC                                  *NEW
      IF(ATHET2.LT.SALPHA) IZ=ID                                  *NEW
      GO TO 26                                                    *NEW
   25 IZ=IG                                                       *NEW
   26 IF(ATHET3.LT.EALPHA.AND.ATHET4.LT.EALPHA) GO TO 27          *NEW
      GO TO 28                                                    *NEW
   27 IZ=IE                                                       *NEW
   28 CONTINUE                                                    *NEW
```

```
01000          GO TO 9160                                                      •NEW
01001     3179 IZ=IQ                                                           •NEW
01002     9168 CONTINUE                                                        •NEW
01003          IF (JPCARD .EQ. 0) GO TO 305
01005          IF(ABS(ZLVLH).LT.0.0495) ZLVLH=.0                               •NEW
01007          IF(ABS(YLVLH).LT.0.0495) YLVLH=.0                               •NEW
01011          IF(ABS(XLVLH).LT.0.0495) XLVLH=.0                               •NEW
01013          IF(ABS(ZIMU).LT.0.0495) ZIMU=.0                                 •NEW
01015          IF(ABS(YIMU).LT.0.0495) YIMU=.0                                 •NEW
01017          IF(ABS(XIMU).LT.0.0495) XIMU=.0                                 •NEW
01021          IF(ZLVLH.GT.359.9495) ZLVLH=.0                                  •NEW
01023          IF(ZIMU.GT.359.9495) ZIMU=.0                                    •NEW
01025          IF(IPTFLG .EQ. 0) WRITE(6,960) IHT,IMT,ST,(NEVENT(J),J=1,3),
01025         • ALT,GDLAT,SCLON,ZLVLH,YLVLH,XLVLH,ZIMU,YIMU,XIMU,YAWSUN,
01025     C                                                                    •NEW
01025     C-----OUTPUT FORMATS ARE ALTERED TO ACCEPT SPECIAL                   •NEW
01025     C      STAR TRACKER CONSTRAINT VIOLATION CODE------                  •NEW
01025     C                                                                    •NEW
01025         •PTCSUN,YAWCOE,PTCCOE,IZ                                         •NEW
01055      960 FORMAT(1X,I3,1X,I2,1X,F4.1,1X,3(A6),2(1X,F5.1),1X,F6.1,         ••-1
01055         •2(1X,3(1X,F5.1)),2(1X,2(1X,F5.1)),1X,A1)                        •NEW
01056          IF(IPTFLG .NE. 0) WRITE(6,970) IHT,IMT,ST,(NEVENT(J),J=1,3),    ••-1
01056         • ALT,GDLAT,SCLON,ZLVLH,YLVLH,XLVLH,ZIMU,YIMU,XIMU,YAWSUN,
01056         •PTCSUN,YAWCOE,PTCCOE,IZ,NAMTAR,YAWTAR,PTCTAR                    •NEW
01111      970 FORMAT(1X,I3,1X,I2,1X,F4.1,1X,3(A6),2(1X,F5.1),1X,F6.1,         ••-1
01111         •2(1X,3(1X,F5.1)),2(1X,2(1X,F5.1)),1X,A1,1X,A3,2(1X,F5.1))       •NEW
01112          GO TO 306                                                       ••-1
01113      305 CONTINUE
01114          IF(ABS(ZLVLH).LT.0.0495) ZLVLH=.0                               •NEW
01116          IF(ABS(YLVLH).LT.0.0495) YLVLH=.0                               •NEW
01120          IF(ABS(XLVLH).LT.0.0495) XLVLH=.0                               •NEW
01122          IF(ABS(ZIMU).LT.0.0495) ZIMU=.0                                 •NEW
01124          IF(ABS(YIMU).LT.0.0495) YIMU=.0                                 •NEW
01126          IF(ABS(XIMU).LT.0.0495) XIMU=.0                                 •NEW
01130          IF(ZLVLH.GT.359.9495) ZLVLH=.0                                  •NEW
01132          IF(ZIMU.GT.359.9495) ZIMU=.0                                    •NEW
01134          IF (IPTFLG .EQ. 0) WRITE (6,960) IHT,IMT,ST,NCARD,NCARD,NCARD,
01134         •ALT,GDLAT,SCLON,ZLVLH,YLVLH,XLVLH,ZIMU,YIMU,XIMU,YAWSUN,
01134         •PTCSUN,YAWCOE,PTCCOE,IZ                                         •NEW
01163          IF (IPTFLG .NE. 0) WRITE (6,970) IHT,IMT,ST,NCARD,NCARD,NCARD,  ••-1
01163         •ALT,GDLAT,SCLON,ZLVLH,YLVLH,XLVLH,ZIMU,YIMU,XIMU,YAWSUN,
01163         •PTCSUN,YAWCOE,PTCCOE,IZ,NAMTAR,YAWTAR,PTCTAR                    •NEW
01215      306 CONTINUE                                                        ••-1
01216          IF(NUMCOM .EQ. 1) GO TO 350
01220          DO 320 J=2,NUMCOM
01223          IJ =(J-1)*3
01224          WRITE(6,980) NEVENT(IJ+1),NEVENT(IJ+2),NEVENT(IJ+3)
01231      980 FORMAT(13X,3(A6))
01232      320 CONTINUE
01232     C
01234      350 CONTINUE
01235          GETWRT = IHR + MN/60.0 + SECS/3600.0
01235     C  THE DESCRIPTOR TAPE IS WRITTEN BELOW.
01235     C
01236          IF(IUWRT .GT. 0) WRITE(IUWRT) GETWRT,ATTSYS,IMUNUM,IVMS,
01236         • ANG1,ANG2,ANG3,IHOLD,XRATE,YRATE,ZRATE,IPTFLG,ALIGN,INSTID,
01236         • IANG1,IANG2,ITYPE1,IDEF1,VAR1,VAR2,VAR3,ITARG1,VAR4,IDIN2,
01236         • IANG12,IANG22,ITYPE2,IDEF2,VAR12,VAR22,VAR32,ITARG2,VAR42,
```

```
01236              • (NEVENT(J),J=1,12),NAMTAR
01236        C
01307              NUMLIN = NUMLIN + NUMCOM
01310              IF (GMTINT .GT. 1.E-4) GO TO 400
01312              IF (IBLANK .NE. 1) CALL CRDFIL(3)
01314              IBLANK = 0
01315              IF(IERR .EQ. 0) GO TO 100
01317              IF(IUWRT .GT. 0) ENDFILE IUWRT
01321              STOP
01322          400 CONTINUE
01323              GMT = GMT + GMTINT/60.0D0
01324              IF (JPCARD .EQ. 0) GO TO 450
01326              CALL CRDFIL(1)
01327              IF (ATTSYS .NE. NBLANK ) CALL CRDFIL(3)
01327        C  THE CALL TO GETDES OBTAINS THE NEXT EVENT SET
01327        C
01331              CALL GETDES(IUREAD,ISTOP)
01331        C
01332              IF (ITAPE .GT. 0 .AND. IERR .LT. 0) RECFLG = - 1.0
01334              IF(RECFLG .LT. 0.)WRITE(ITAPE) RECFLG,PRTFLG,YEAR,GMONTH,GDAY,
01334             •GHR,GMIN,GSEC,GET,(RKMDP(I),I=1,3),(VKMDP(I),I=1,3),(DV(I),I=1,3),
01334             • YIMUDP,ZIMUDP,XIMUDP,RMAGKM,DECGCN,RASGCN,VMAGKM,GAMI,PSII,
01334             • VALTKM,VEHGDL,VEHLON,VELREL,GAMREL,PSIREL,GRAS,REV,AKM,E,RADINC,
01334             • ASCNR,ARGPR,TRUEAN,PERIOD,DYNPR,DRAGKG,LIFTKG,WGTKG,THRKG,ISPSEC,
01334             • EGRAVC,SHADOW,(ATTECI(1,J),J=1,3),(ATTECI(2,J),J=1,3),
01334             • (ATTECI(3,J),J=1,3),YLVLHR,ZLVLHR,XLVLHR,ALSR,BTSR,GMSR,PTSUNR,
01334             • YWSUNR,PTCOER,YWCOER,(RSUNKM(I),I=1,3),(SPARE(I),I=1,14)
01462              IF (RECFLG .LT. 0.)ENDFILE ITAPE
01464              IF (IERR .NE. 0 ) STOP
01466              CALL CRDFIL(1)
01467              JPCARD = 0
01470              TNEXT = IHR + MN/60 + SECS/3600
01471              GMTNXT = TNEXT + BASTIM
01472          450 CONTINUE
01473              IF ( (GMTNXT-GMT) .LE. 1.E-5 ) CALL CRDFIL(1)
01475              IF ( (GMTNXT-GMT) .LE. 1.E-5 ) GO TO 120
01477              ATTSYS = NBLANK
01500              ALIGN = 0
01501              IF (IERR .EQ. 0) GO TO 150
01503              STOP
01504              END

    END OF COMPILATION:         NO  DIAGNOSTICS.
  SAPT              SYMBOLIC                               27 JUN 74  15:33:38   0  02621512   14   424  (DELETED)
  SAPT     CODE     RELOCATABLE                            27 JUN 74  15:33:38   1  01746122   84     1  (DELETED)
                                                                                 0  01746246   14   157
```

APPENDIX C: RESULTS OF STAR TRACKER CONSTRAINT VIOLATION ANALYSIS FOR SORTIE OPTION 2 OF BRM 2 WITH PLATFORM ALINEMENTS PERFORMED IN THE INERTIAL HOLD MODE AT THE INERTIAL ATTITUDE JUST PRIOR TO THE ALINEMENT *

* Included are printouts for Alpha (α) + 20° for earth pointing constraint violations, printed after each event; and angles Theta (Θ) for Star Tracker 1 and 2 and the Sun, Star Tracker 3 and the Sun, Star Trackers 1 and 2 and the Earth, and Star Tracker 3 and the Earth, printed in a line of four numbers prior to each platform alinement.

PRELIMINARY BRM MISSION 2 - OPTION 2
SHUTTLE ATTITUDE AND POINTING TIME LINE WITH STAR TRACKER CONSTRAINTS INDICATED

GET				VEHICLE POSITION			LVLH ATTITUDE			ECI ATTITUDE			LOOK ANGLES TO SUN		LOOK ANGLES TO EARTH		LOOK ANGLES TO TARGET		
HRS	MN	SECS	EVENT	ALT N MI	LAT DEG	LON DEG	YAW DEG	PITCH DEG	ROLL DEG	YAW DEG	PITCH DEG	ROLL DEG	YAW DEG	PITCH DEG	YAW DEG	PITCH DEG	TARG ID	YAW DEG	PITCH DEG
~~50~~	~~0~~	~~.0~~	~~MNVR TO INERTIAL~~ HOLD ATT FOR EXP SETUP AND CHECKOUT	~~233.6~~	~~-50.5~~	~~93.8~~	~~90.0~~	~~.0~~	~~-.0~~	~~257.9~~	~~34.9~~	~~19.8~~	~~356.4~~	~~345.4~~	~~.0~~	~~270.0~~			
89.39802																			
51	0	.0	TDRS 41W	235.3	44.2	-21.4	89.8	.1	232.0	257.9	34.9	19.8	356.5	345.5	269.9	38.0			
89.39802																			
~~51~~	~~0~~	~~.0~~	~~TDRS 171W~~	~~235.3~~	~~44.2~~	~~-21.4~~	~~89.8~~	~~.1~~	~~232.0~~	~~257.9~~	~~34.9~~	~~19.8~~	~~356.5~~	~~345.5~~	~~269.9~~	~~38.0~~			
89.48655																			
53	0	.0	BEGIN INERTIAL HOLD FOR SLEEP	233.2	-36.5	21.6	90.0	.0	.0	257.3	34.9	43.5	3.2	345.7	.0	270.0			
89.40141																			
55	0	.0	BEGIN SLEEP PERIOD	235.2	-24.0	122.2	90.2	359.7	103.9	257.3	34.9	43.5	3.3	345.8	89.7	13.9			
89.50570																			
63	0	.0	END SLEEP PERIOD	232.7	22.2	34.8	89.3	358.6	159.9	257.3	34.9	43.5	3.5	346.0	85.9	69.9			
89.48935																			
64	24	.0	TDRS 41W	233.1	-6.4	-7.5	90.3	358.2	124.7	257.3	34.9	43.5	3.5	346.1	67.8	34.7			
89.48935																			
64	24	.0	TDRS 171W	233.1	-6.4	-7.5	90.3	358.2	124.7	257.3	34.9	43.5	3.5	346.1	67.8	34.7			
89.51723																			
98.94534			102.96961 27.14784 116.39949																
64	30	.0	PLATFORM ALINE	232.4	12.7	4.5	89.6	358.3	147.9	257.3	34.9	43.5	3.5	346.1	86.7	57.9	C		
89.32095																			
64	45	.0	MNVR TO LVLH ATT FOR NV-1 CAL	237.2	52.0	54.2	.0	.0	180.0	335.6	346.7	36.0	268.7	346.5	.0	90.0			
89.60740																			
65	15	.0	BEGIN INERTIAL HOLD	230.3	-7.8	169.5	-.0	.0	180.0	91.7	54.0	103.6	258.3	6.9	.0	90.0			
89.43381																			
65	55	.0	MNVR TO LVLH ATT FOR NV-1 CAL	234.4	-12.9	-35.3	.0	.0	180.0	228.9	307.8	111.[illegible]	[illegible].4	358.8	.0	90.0			
89.33717																			
66	25	.0	BEGIN INERTIAL HOLD	236.8	53.9	73.8	-.0	.0	180.0	350.8	8.6	35.3	263.1	348.4	.0	90.0			
89.48037																			
67	0	.0	MNVR TO LVLH ATT FOR NV-1 OPS	233.3	-42.6	177.4	.0	.0	180.0	143.6	27.3	139.9	266.6	13.0	.0	90.0			
89.32314																			
67	50	.0	BEGIN INERTIAL HOLD	237.1	50.1	1.0	-.0	.0	180.0	332.3	343.2	36.7	270.4	346.6	.0	90.0			
89.52163																			
69	10	.0	MNVR TO LVLH ATT FOR NV-2 EARTH OPS	232.3	15.2	-64.7	.0	.0	180.0	285.1	309.0	65.2	260.7	352.2	.0	90.0			
89.36457																			
69	35	.0	BEGIN INERTIAL HOLD	236.1	48.0	47.5	.0	-.0	180.0	359.4	20.7	37.7	260.9	350.3	.0	90.0			
89.34317																			
71	45	.0	MNVR TO LVLH ATT FOR NV-1 AND LO-77R OPS	236.6	-53.5	135.0	.0	-.0	180.0	157.1	9.5	144.6	270.9	13.1	.0	90.0			
89.39530																			
72	45	.0	BEGIN INERTIAL	235.4	38.9	15.7	-.0	.0	180.0	9.6	32.2	42.5	259.3	352.5	.0	90.0			

ORIGINAL PAGE IS OF POOR QUALITY

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             HOLD
 89.50041
73 38    .0 MNVR TO LVLH ATT    232.8 -20.1 -158.4     -.0    .0 180.0  214.9 311.7 120.7  282.8   2.5     .0  90.0
             FOR NV-1 OPS AND
             EO-7/8 OPS
 89.42680
74 25    .0 BEGIN INERTIAL      234.6  18.7   10.8     -.0    .0 180.0   37.1  49.2  61.1  257.2 357.8    .0  90.0
             HOLD
 89.32832
75  0    .0 MNVR TO LVLH ATT    237.0 -49.4  141.4      .0   -.0 180.0  176.6 341.5 142.9  277.5  10.6     .0  90.0
             FOR NV-1 OPS
 89.37355
75 32    .0 TDRS 41W            235.9  43.1 -132.0  179.9  56.3 359.9  176.6 341.5 142.9  277.5  10.6  180.0 326.3
 89.37355
75 32    .0 TDRS 171W           235.9  43.1 -132.0  179.9  56.3 359.9  176.6 341.5 142.9  277.5  10.6  180.0 326.3
 89.30029
  74.40482   19.71246  141.91470   76.84741
75 38    .0 PLATFORM ALINE      237.7  53.9 -102.1  179.9  33.1   -.0  176.6 341.5 142.9  277.5  10.6  180.0 303.1 D
 89.39677
75 53    .0 BEGIN INERTIAL      235.3  33.8  -25.6     -.0    .0 180.0   15.1  37.4  46.0  258.9 353.4    .0  90.0
             HOLD
 89.52421
76 23    .0 MNVR TO LVLH ATT    232.3  -1.8  142.7     -.0   -.0 180.0  249.0 304.9  92.8  282.7 358.5    .0  90.0
             FOR NV-1 OPS
 89.31220
76 50    .0 MNVR TO INERTIAL    237.4  53.4 -112.2   90.0    .0    .0  252.4  34.9 167.6    4.6  11.9    .0 270.0
             HOLD ATT FOR SLEEP
 89.39900
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SHUTTLE ATTITUDE AND POINTING TIME LINE

GET HRS MN SECS	EVENT	VEHICLE POSITION ALT N MI	LAT DEG	LON DEG	LVLH ATTITUDE YAW DEG	PITCH DEG	ROLL DEG	ECI ATTITUDE YAW DEG	PITCH DEG	ROLL DEG	LOOK ANGLES TO SUN YAW DEG	PITCH DEG	LOOK ANGLES TO EARTH YAW DEG	PITCH DEG	LOOK ANGLES TO TARGET TARG ID	YAW DEG	PITCH DEG
79 0 .0	BEGIN SLEEP PERIOD	235.3	31.3	-70.4	90.0	.0	36.6	252.4	34.9	167.6	4.6	11.9	90.0	308.6			
89.58441																	
87 0 .0	END SLEEP PERIOD	230.8	-14.5	-156.9	90.3	1.2	94.6	252.4	34.9	167.6	4.3	12.0	91.2	4.6			
89.50941																	
86 39 .0	TDRS 41W	232.6	-32.5	-166.1	91.0	1.2	117.4	252.4	34.9	167.6	4.2	12.0	91.3	27.4			
89.50941																	
88 39 .0	TDRS 171W	232.6	-32.5	-166.1	91.0	1.2	117.4	252.4	34.9	167.6	4.2	12.0	91.3	27.4			
89.41213																	
73.01617	103.77608 34.37802 122.56078																
86 45 .0	PLATFORM ALINE	235.0	-47.6	-144.4	91.4	.7	140.6	252.4	34.9	167.6	4.2	12.0	91.1	50.6	C		
89.34898																	
89 0 .0	MNVR TO LVLH ATT FOR NV-1 CAL	236.5	-44.3	-60.3	-.0	.0	180.0	180.2	334.1	140.5	276.5	10.8	.0	90.0			
89.46325																	
89 30 .0	BEGIN INERTIAL HOLD	233.7	44.2	17.1	.0	-.0	180.0	320.9	334.3	39.4	277.1	349.6	.0	90.0			
89.47289																	
90 15 .0	MNVR TO LVLH ATT FOR NV-1 CAL	233.5	-40.4	179.6	.0	.0	180.0	136.4	30.1	138.6	261.8	9.6	.0	90.0			
89.53268																	
90 45 .0	BEGIN INERTIAL HOLD	232.1	-9.6	-51.2	.0	.0	180.0	230.3	306.5	106.2	282.2	3.2	.0	90.0			
89.32501																	
92 0 .0	MNVR TO LVLH ATT FOR NV-1 AND NV-2 EARTH OPS	237.1	-54.4	-139.2	.0	.0	180.0	164.8	353.1	144.8	270.9	12.6	.0	90.0			
89.57644																	
93 5 .0	INERTIAL HOLD	231.0	8.5	94.2	.0	-.0	180.0	52.4	53.9	75.8	257.9	356.6	.0	90.0			
89.53321																	
93 50 .0	MNVR TO LVLH ATT FOR NV-2 EARTH OPS	232.0	-13.3	-100.8	.0	-.0	180.0	222.9	307.9	111.6	281.7	4.8	.0	90.0			
89.40639																	
94 30 .0	BEGIN INERTIAL HOLD	235.1	33.1	51.6	-.0	.0	180.0	12.4	38.0	46.5	261.5	350.6	.0	90.0			
89.52697																	
95 30 .0	MNVR TO LVLH ATT FOR NV-1 OPS	232.2	8.7	-110.6	-.0	.0	180.0	267.7	306.3	74.9	282.6	359.4	.0	90.0			
89.56790																	
96 10 .0	BEGIN INERTIAL HOLD	231.2	12.1	44.6	-.0	.0	180.0	44.8	52.6	70.2	258.3	355.1	.0	90.0			
89.44310																	
96 50 .0	MNVR TO LVLH ATT FOR EO-7/8 OPS	234.2	-31.9	-162.6	.0	.0	180.0	193.5	320.9	132.5	278.4	9.6	.0	90.0			
89.30536																	
97 20 .0	BEGIN INERTIAL HOLD	237.5	52.9	-78.0	.0	-.0	180.0	331.0	348.6	35.7	275.1	348.4	.0	90.0			
89.39484																	
98 20 .0	MNVR TO LVLH ATT FOR NV-2 EARTH OPS AND EO-7/8 OPS	235.4	-40.3	164.1	.0	.0	180.0	183.1	329.3	138.4	276.0	11.3	.0	90.0			
89.34343																	

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98 55	.0	BEGIN INERTIAL HOLD	236.6	54.7	-89.9	-.0	-.0	180.0	335.1	354.9	35.0	273.9	347.8	.0	90.0	
89.51596																
99 30	.0	MNVR TO LVLH ATT FOR NV-1 OPS	232.5	-31.2	27.3	.0	.0	180.0	123.5	39.5	132.2	258.6	5.8	.0	90.0	
89.36811																
99 54	.0	TDRS 41W	236.0	-37.8	143.7	178.6	87.2	358.5	123.5	39.5	132.2	258.6	5.8	180.1	357.2	
89.36811																
99 54	.0	TDRS 171W	236.0	-37.6	143.7	178.6	87.2	356.5	123.5	39.5	132.2	258.6	5.8	180.1	357.2	
89.42457																
79.18516	1.84867	110.98168	71.44991													
100 0	.0	PLATFORM ALINE	234.7	-20.4	159.8	179.9	64.0	359.8	123.5	39.5	132.2	258.6	5.8	180.1	334.0	D
89.50235																
100 15	.0	BEGIN INERTIAL HOLD	232.8	26.7	-168.6	.0	.0	180.0	297.3	316.7	51.8	282.0	355.5	.0	90.0	
89.52514																
101 45	.0	MNVR TO LVLH ATT FOR NV-2 EARTH OPS	232.2	17.4	160.7	.0	.0	180.0	282.6	310.2	62.3	282.7	358.4	.0	90.0	
89.41299																
102 15	.0	MNVR TO INERTIAL HOLD FOR SLEEP	234.9	34.0	-67.4	90.0	.0	.0	248.0	34.9	132.5	7.1	10.8	.0	270.0	
89.36879																
103 0	.0	BEGIN SLEEP PERIOD	236.0	-38.2	96.0	90.1	359.9	174.0	248.0	38.9	132.5	7.0	10.8	89.2	84.0	
89.53301																
111 0	.0	END SLEEP PERIOD	232.1	6.7	11.9	89.8	358.7	230.0	248.0	34.9	132.5	6.8	11.0	271.7	40.0	
89.41853																
112 24	.0	TDRS 41W	234.8	-21.9	-30.3	90.7	358.6	194.7	248.0	34.9	132.5	6.7	11.1	275.5	75.2	
89.41853																
112 24	.0	TDRS 171W	234.8	-21.9	-30.3	90.7	358.6	194.7	248.0	34.9	132.5	6.7	11.1	275.5	75.2	
89.51991																

SHUTTLE ATTITUDE AND POINTING TIME LINE

GET HRS MN SECS	EVENT	VEHICLE POSITION ALT N MI	LAT DEG	LON DEG	LVLH ATTITUDE YAW DEG	PITCH DEG	ROLL DEG	ECI ATTITUDE YAW DEG	PITCH DEG	ROLL DEG	LOOK ANGLES TO SUN YAW DEG	PITCH DEG	LOOK ANGLES TO EARTH YAW DEG	PITCH DEG	LOOK ANGLES TO TARGET TARG ID	YAW DEG	PITCH DEG
73.93813 106.29785 32.98704 49.06826																	
112 30 .0	PLATFORM ALINE	232.4	-3.1	-17.7	90.1	358.4	218.0	246.0	34.9	132.5	6.7	11.1	272.6	52.0	E		
89.33221																	
113 45 .0	MNVR TO LVLH ATT FOR NV-1 CAL	236.9	-52.0	-97.4	.0	.0	180.0	165.5	346.4	144.0	268.0	13.4	.0	90.0			
89.47314																	
114 15 .0	BEGIN INERTIAL HOLD	233.5	33.8	-14.6	.0	.0	180.0	304.0	322.9	45.8	283.0	356.0	.0	90.0			
89.54088																	
114 45 .0	MNVR TO LVLH ATT FOR NV-1 CAL	231.9	17.6	117.4	-.0	-.0	180.0	31.3	49.9	62.5	260.7	350.0	.0	90.0			
89.32237																	
115 15 .0	BEGIN INERTIAL HOLD	237.1	-55.0	-139.5	.0	-.0	180.0	158.3	356.1	145.0	264.9	12.7	.0	90.0			
89.52450																	
115 35 .0	MNVR TO LVLH ATT FOR NV-1 OPS	232.3	-6.6	-67.2	.0	-.0	180.0	231.9	305.6	101.1	281.3	7.7	.0	90.0			
89.43507																	
116 40 .0	BEGIN INERTIAL HOLD	234.4	-47.3	149.8	.0	.0	180.0	139.4	21.4	142.1	258.8	8.1	.0	90.0			
89.55260																	
118 45 .0	MNVR TO LVLH ATT FOR NV-2 EARTH OPS AND EO-7/8 OPS	231.6	5.7	-106.8	-.0	.0	180.0	257.3	305.5	79.8	283.0	5.2	.0	90.0			
89.46132																	
119 25 .0	BEGIN INERTIAL HOLD	233.8	15.0	48.3	-.0	-.0	180.0	34.9	51.3	65.9	260.5	349.6	.0	90.0			
89.55415																	
120 15 .0	MNVR TO LVLH ATT FOR NV-1 OPS AND NV-2 OPS	231.5	-4.1	-136.5	-.0	-.0	180.0	236.4	305.1	96.7	281.6	8.1	.0	90.0			
89.55463																	
121 0 .0	BEGIN INERTIAL HOLD	231.5	8.9	28.7	.0	-.0	180.0	46.2	53.8	75.1	259.3	350.6	.0	90.0			
89.52998																	
121 45 .0	MNVR TO LVLH ATT FOR EO-7/8 OPS	232.1	-13.8	-166.3	.0	-.0	180.0	216.8	308.1	112.2	279.6	10.6	.0	90.0			
89.31809																	
122 12 .0	BEGIN INERTIAL HOLD	237.2	55.2	-77.4	.0	-.0	180.0	333.0	358.3	34.9	278.1	348.2	.0	90.0			
89.43719																	
122 50 .0	MNVR TO LVLH ATT FOR NV-1 OPS	234.4	-42.1	46.0	-.0	.0	180.0	132.2	28.2	139.6	256.7	5.4	.0	90.0			
89.29574																	
123 45 .0	BEGIN INERTIAL HOLD	237.8	55.1	-101.4	.0	-.0	180.0	332.6	358.1	34.9	278.5	348.3	.0	90.0			
89.36388																	
124 39 .0	TDRS 41W	236.4	-47.5	110.2	180.2	331.2	359.9	332.6	358.1	34.9	278.6	348.3	359.9	298.8			
89.35388																	
124 39 .0	TDRS 171W	236.4	-47.5	110.2	180.2	331.2	359.9	332.6	358.1	34.9	278.6	348.3	359.9	298.8			
89.42774																	

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96.70908	21.17232	122.98055	96.65373														
124	45	.0	PLATFORM ALINE	234.6	-32.3	131.8	180.3	308.0	359.8	332.6	358.1	34.9	278.6	348.3	359.8	322.0	D
89.52720																	
125	0	.0	MNVR TO LVLH ATT FOR NV-1 OPS AND NV-2 EARTH OPS	232.2	14.4	164.3	-.0	.0	180.0	273.0	308.6	66.3	284.0	4.1	.0	90.0	
89.41005																	
125	30	.0	MNVR TO INERTIAL ATT FOR SLEEP	235.0	36.6	-64.7	90.0	.0	-.0	243.6	34.8	136.2	2.4	14.4	.0	270.0	
89.37492																	
127	0	.0	BEGIN SLEEP PERIOD	235.9	44.4	-99.3	89.8	.1	348.0	243.6	34.8	136.2	2.3	14.5	269.4	282.0	
89.57663																	
135	0	.0	END SLEEP PERIOD	231.0	1.2	-179.1	89.9	1.5	44.0	243.6	34.8	136.2	2.0	14.7	92.1	314.0	
89.39850																	
136	24	.0	TDRS 41W	235.3	29.4	137.4	89.0	1.3	8.7	243.6	34.8	136.2	2.0	14.7	98.8	278.8	
89.39850																	
136	24	.0	TDRS 171W	235.3	29.4	137.4	89.0	1.3	8.7	243.6	34.8	136.2	2.0	14.7	98.8	278.8	
89.53533																	
70.30528	101.40363	143.00717	115.23689														
136	30	.0	PLATFORM ALINE	232.0	10.9	151.2	89.6	1.6	32.0	243.6	34.8	136.2	2.0	14.7	93.1	302.0	
89.49382																	
136	45	.0	MNVR TO LVLH ATT FOR NV-1 CAL	233.0	-35.4	-175.3	.0	.0	180.0	121.7	35.5	135.4	254.1	.7	.0	90.0	
89.29719																	
137	45	.0	BEGIN INERTIAL HOLD	237.7	54.6	61.7	-.0	-.0	180.0	335.3	5.8	35.1	279.6	347.1	.0	90.0	
89.35832																	

SHUTTLE ATTITUDE AND POINTING TIME LINE

GET		VEHICLE POSITION			LVLH ATTITUDE			ECI ATTITUDE			LOOK ANGLES TO SUN		LOOK ANGLES TO EARTH		LOOK ANGLES TO TARGET		
HRS MN SECS	EVENT	ALT N MI	LAT DEG	LON DEG	YAW DEG	PITCH DEG	ROLL DEG	YAW DEG	PITCH DEG	ROLL DEG	YAW DEG	PITCH DEG	YAW DEG	PITCH DEG	TARG ID	YAW DEG	PITCH DEG
~~139 12 .0~~	~~MNVR TO LVLH ATT~~ FOR NV-2 EARTH OPS	~~236.3~~	~~51.9~~	~~.2~~	~~.0~~	~~.0~~	~~180.0~~	~~321.5~~	~~346.6~~	~~36.0~~	284.2	352.0	.0	90.0			
89.58815 139 40 .0	BEGIN INERTIAL HOLD	230.7	-1.4	111.6	-.0	.0	180.0	64.3	55.1	92.8	257.8	349.1	.0	90.0			
89.35613 ~~140 10 .0~~	~~MNVR TO LVLH ATT~~ FOR NV-1 OPS	~~236.3~~	~~-46.7~~	~~-124.4~~	~~-.0~~	~~.0~~	~~180.0~~	~~167.7~~	~~337.3~~	~~141.8~~	265.2	15.7	.0	90.0			
89.49162 140 36 .0	BEGIN INERTIAL HOLD	233.0	30.7	-59.2	.0	-.0	180.0	295.1	320.1	48.1	286.3	1.8	.0	90.0			
89.38033 ~~141 48 .0~~	~~MNVR TO LVLH ATT~~ FOR NV-1 OPS AND ED-7/8 OPS	~~235.7~~	~~-34.3~~	~~-130.1~~	~~-.0~~	~~.0~~	~~180.0~~	~~182.0~~	~~323.1~~	~~134.4~~	270.4	16.6	.0	90.0			
89.49988 142 38 .0	BEGIN INERTIAL HOLD	232.8	24.1	47.3	.0	.0	180.0	15.6	45.6	54.7	265.7	343.8	.0	90.0			
89.50961 143 40 .0	MNVR TO LVLH ATT FOR NV-2 EARTH OPS	232.6	24.4	-111.9	.0	.0	180.0	285.9	314.9	54.0	286.2	4.7	.0	90.0			
89.40041 144 6 .0	BEGIN INERTIAL HOLD	235.2	38.6	9.4	.0	-.0	180.0	356.4	32.5	42.6	271.9	343.2	.0	90.0			
89.46377 145 0 .0	MNVR TO LVLH ATT FOR NV-1 OPS AND ED-7/8 OPS	233.7	-16.7	-162.6	-.0	.0	180.0	207.1	309.6	116.4	276.6	15.7	.0	90.0			
89.36439 145 25 .0	BEGIN INERTIAL HOLD	236.1	52.9	-90.0	-.0	-.0	180.0	322.0	348.9	35.6	285.1	351.9	.0	90.0			
89.49424 146 6 .0	MNVR TO LVLH ATT FOR NV-1 OPS AND ED-7/8 OPS	233.0	-42.3	51.9	.0	-.0	180.0	128.0	28.0	139.7	253.0	2.1	.0	90.0			
89.32298 147 6 .0	BEGIN INERTIAL HOLD	237.1	51.8	-64.5	-.0	-.0	180.0	339.5	14.0	36.1	279.2	345.3	.0	90.0			
89.33117 147 51 .0	TDRS 41W	236.9	-53.7	94.9	180.1	6.0	-.0	339.5	14.0	36.1	279.3	345.3	180.2	276.0			
89.33117 147 51 .0	TDRS 171W	236.9	-53.7	94.9	180.1	6.0	-.0	339.5	14.0	36.1	279.3	345.3	180.2	276.0			
89.37751 99.72243 23.16065 157.78198 89.32535 147 57 .0	PLATFORM ALINE	235.8	-42.6	124.4	180.1	342.8	359.9	339.5	14.0	36.1	279.3	345.3	359.8	267.2	D		
89.54282 148 12 .0	MNVR TO LVLH ATT FOR NV-1 OPS AND ED-7/8 OPS	231.8	1.9	162.0	.0	.0	180.0	243.7	304.9	86.4	282.2	12.6	.0	90.0			
89.38776 148 45 .0	MNVR TO INERTIAL	235.5	39.1	-62.1	90.0	-.0	.0	239.2	34.8	139.8	357.0	17.3	.0	270.0			

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           ATT FOR SLEEP
   89.35034
151  0    .0 BEGIN SLEEP PERIOD 236.4 -49.5    63.5    90.3 359.9 162.0  239.2  34.8 139.8  356.9  17.4   89.5  72.0
   89.51653
159  0    .0 END SLEEP PERIOD   232.4  -9.0  -10.2    90.3 358.5 216.0  239.2  34.8 139.8  356.6  17.5  272.5  52.0
   87.35608
160  9    .0 TDRS 41W           236.3 -52.8 -135.0    91.7    .4 124.7  239.2  34.8 139.8  356.6  17.5   90.5  34.7
   89.35608
160  9    .0 TDRS 171W          236.3 -52.8 -135.0    91.7    .4 124.7  239.2  34.8 139.8  356.6  17.5   90.5  34.7
   89.33117
    67.47160   96.03570   27.06258  115.92986
160 15    .0 PLATFORM ALINE     236.9 -54.2  -97.2    91.8 357.7 147.9  239.2  34.8 139.8  356.6  17.5   89.5  57.9 C
   87.54342
161 30    .0 START PAYLOAD      231.8 -23.8  155.9    90.9   1.7  78.0  239.2  34.8 139.8  356.5  17.5   91.8 348.0
           CLOSEOUT
```

APPENDIX D: RESULTS OF STAR TRACKER CONSTRAINT VIOLATIONS ANALYSIS FOR PRELIMINARY BASELINE REFERENCE MISSION 1 USING PLATFORM ALINEMENTS IN THE INERTIAL HOLD MODE AT AN INITIAL LVLH ATTITUDE OF 0, 0, 0 *

* Included are printouts of Alpha (α) + 20° for Earth pointing constraint violations, printed after each event; and Angles Theta (Θ) for Star Trackers 1 and 2 and the Sun, Star Tracker 3 and the Sun, Star Trackers 1 and 2 and the Earth, and Star Tracker 3 and the Earth, printed in a set of four numbers prior to each Platform Alinement.

PRELIMINARY BASELINE REFERENCE MISSION 1
SHUTTLE ATTITUDE AND POINTING TIME LINE
WITH STAR TRACKER CONSTRAINTS INDICATED

GET		VEHICLE POSITION			LVLH ATTITUDE			ECI ATTITUDE			LOOK ANGLES TO SUN		LOOK ANGLES TO EARTH		LOOK ANGLES TO TARGET		
HRS MN SECS	EVENT	ALT N MI	LAT DEG	LON DEG	YAW DEG	PITCH DEG	ROLL DEG	YAW DEG	PITCH DEG	ROLL DEG	YAW DEG	PITCH DEG	YAW DEG	PITCH DEG	TARG ID	YAW DEG	PITCH DEG
0 45 55.5	MNVR TO ATT FOR ORB INSERTION	152.8	-29.4	74.2	359.8	13.1	.0	248.3	6.0	298.4	194.3	352.7	180.0	283.1			
93.23810																	
1 30 .0	BEGIN ON-ORBIT OPERATIONS	152.8	29.3	-121.2	180.1	350.7	180.0	248.3	6.0	298.4	194.3	352.8	360.0	80.7			
93.23769																	
3 0 .0	BEGIN SLEEP PERIOD	152.8	29.3	-143.9	179.9	350.8	180.0	248.3	6.0	298.4	194.4	352.8	.0	80.8			
93.23775																	
10 30 .0	END SLEEP PERIOD	152.8	29.3	102.5	178.7	351.5	179.9	248.3	6.0	298.4	194.6	353.1	.4	81.5			
93.28035																	
11 24 .0	TDRS 41W	152.0	-23.9	-51.2	.0	.0	.0	287.3	344.0	294.5	204.6	311.0	.0	270.0		311.8	59.7
93.28035																	
11 24 .0	TDRS 171W	152.0	-23.9	-51.2	.0	.0	.0	287.3	344.0	294.5	204.6	311.0	.0	270.0		184.6	325.5
93.33013																	
158.73898 71.00446 180.00000 90.00000																	
11 30 .0	PLATFORM ALINE	151.1	-14.9	-29.1	.0	-.0	.0	311.3	335.5	286.1	228.8	291.3	.0	270.0	8		
93.23809																	
12 0 .0	INITIATE TUG DEPLOYMENT	152.8	29.3	79.7	-.0	-.0	.0	74.9	359.4	241.0	343.5	15.0	.0	270.0			
93.28902																	
12 11 9.0	TUG SEPARATION	151.9	21.0	125.6	-.0	-.0	-.0	115.5	19.4	248.0	330.1	56.5	.0	270.0			
93.25559																	
12 40 .0	INITIATE LOS ATT	152.5	-27.2	-132.9	.0	.0	.0	237.1	10.1	297.3	196.1	4.3	.0	270.0			
93.23849																	
27 0 .0	BEGIN SLEEP PERIOD	152.8	29.3	-147.5	177.8	341.3	180.0	237.1	10.1	297.3	196.4	4.8	.1	71.3			
93.30793																	
35 0 .0	END SLEEP PERIOD	151.5	-15.4	-152.5	4.3	318.1	356.0	237.1	10.1	297.3	196.6	5.0	355.6	312.1			
93.30695																	
36 54 .0	TDRS 41W	151.5	-22.4	-78.0	.0	-.0	.0	283.7	342.1	293.3	209.2	315.1	.0	270.0		352.7	40.8
93.30695																	
36 54 .0	TDRS 171W	151.5	-22.4	-78.0	.0	-.0	.0	283.7	342.1	293.3	209.2	315.1	.0	270.0		198.3	348.3
93.36311																	
153.63131 66.01779 180.00000 90.00000																	
37 0 .0	PLATFORM ALINE	150.5	-12.8	-56.4	.0	-.0	.0	308.2	334.3	284.0	231.2	296.4	.0	270.0	8		
93.31887																	
48 54 .0	TDRS 41W	151.3	-21.6	100.0	.0	-.0	.0	282.1	341.3	292.6	211.3	317.1	.0	270.0		175.9	308.1
93.31887																	
48 54 .0	TDRS 171W	151.3	-21.6	100.0	.0	-.0	.0	282.1	341.3	292.6	211.3	317.1	.0	270.0		19.9	351.9
93.37779																	
151.20333 63.63648 180.00000 90.00000																	
49 0 .0	PLATFORM ALINE	15[illegible].2	-11.8	121.4	.0	-.0	.0	306.8	333.8	283.0	232.2	298.8	.0	270.0	8		
93.24220																	
51 0 .0	BEGIN SLEEP PERIOD	152.7	29.2	-150.9	179.8	60.2	180.1	306.8	333.8	283.0	232.2	298.9	180.1	29.8			
93.28259																	
59 0 .0	END SLEEP PERIOD	152.0	-17.2	-156.8	178.9	300.[illegible]	182.4	306.8	333.8	283.0	232.1	299.2	358.6	30.9			
93.33046																	
60 54 .0	TDRS 41W	151.1	-20.9	-82.0	-.0	.0	.0	280.5	340.4	291.9	213.2	319.1	.0	270.0		358.9	37.7
93.33046																	
60 54 .0	TDRS 171W	151.1	-20.9	-82.0	-.0	.0	.0	280.5	340.4	291.9	213.2	319.1	.0	270.0		201.4	352.0
93.39191																	
148.76187 61.24009 180.00000 90.00000																	

```
61  0   .0 PLATFORM ALINE       149.9 -10.8  -60.8     .0   -.0    .0 305.5 333.3 281.9  233.1 301.2        .0 270.0 B
 93.34169
72 54   .0 TDRS 41W             150.9 -20.0   95.9     .0    .0    .0 279.0 339.6 291.1  215.1 321.2        .0 270.0          181.8 310.7
 93.34169
72 54   .0 TDRS 171W            150.9 -20.0   95.9     .0    .0    .0 279.0 339.6 291.1  215.1 321.2        .0 270.0           22.9 348.2
 93.40545
 146.30842    58.83363  180.00000    90.00000
73  0   .0 PLATFORM ALINE       149.7  -9.8  117.0     .0   -.0   -.0 304.2 332.8 280.8  233.9 303.7        .0 270.0 B
 93.24853
75  0   .0 BEGIN SLEEP PERIOD 152.6  28.8 -154.3  179.9  60.1 180.2 304.2 332.8 290.8  233.9 303.8  180.1  29.9
 93.25729
83  0   .0 END SLEEP PERIOD     152.5 -19.0 -160.9  179.1 300.8 182.2 304.2 332.8 280.8  233.8 304.1  358.7  30.8
 93.35256
84 54   .0 TDRS 41W             150.7 -19.2  -86.1    -.0   -.0    .0 277.5 338.7 290.3  216.9 323.2        .0 270.0            4.5  34.4
 93.35256
84 54   .0 TDRS 171W            150.7 -19.2  -86.1    -.0   -.0    .0 277.5 338.7 290.3  216.9 323.2        .0 270.0          204.2 355.7
 93.41835
 143.84460    56.42236  180.00000    90.00000
85  0   .0 PLATFORM ALINE       149.4  -8.7  -65.2    -.0    .0   -.0 303.0 332.4 279.6  234.6 306.2        .0 270.0 B
 93.36303
96 54   .0 TDRS 41W             150.5 -18.3   91.9     .0    .0    .0 276.1 338.0 289.4  218.6 325.3        .0 270.0          187.1 313.5
 93.36303
96 54   .0 TDRS 171W            150.5 -18.3   91.9     .0    .0    .0 276.1 338.0 289.4  218.6 325.3        .0 270.0           25.5 344.5
 93.43058
 141.37226    54.01178  180.00000    90.00000
97  0   .0 PLATFORM ALINE       149.2  -7.6  112.6     .0   -.0   -.0 301.8 332.1 278.4  235.3 308.6        .0 270.0 B
 93.24094
98  0   .0 BEGIN SLEEP PERIOD 152.8 -20.1  -28.4  180.0 300.1 180.2 301.8 332.1 278.4  235.3 308.7  359.9  30.1
 93.43926
106  0  .0 END SLEEP PERIOD     149.0  -6.8  -24.1     .3 359.3   1.3 301.8 332.1 278.4  235.2 309.0   61.0 271.5
 93.37311
108 54  .0 TDRS 41W             150.3 -17.4  -90.1     .0    .0    .0 274.7 337.2 268.5  220.2 327.4        .0 270.0            9.6  30.9
 93.37311
108 54  .0 TDRS 171W            150.3 -17.4  -90.1     .0    .0    .0 274.7 337.2 288.5  220.2 327.4        .0 270.0          206.7 359.6
 93.44211
 138.89338    51.60782  180.00000    90.00000
109  0  .0 PLATFORM ALINE       149.0  -6.5  -69.6    -.0   -.0   -.0 300.7 331.7 277.2  235.8 311.1        .0 270.0 B
 93.38276
120 54  .0 TDRS 41W             150.1 -16.4   87.8    -.0    .0   -.0 273.3 336.5 287.6  221.7 329.6        .0 270.0          191.9 316.4
 93.38276
120 54  .0 TDRS 171W            150.1 -16.4   87.8    -.0    .0   -.0 273.3 336.5 287.6  221.7 329.6        .0 270.0           27.8 340.7
 93.45289
 136.41014    49.21693  180.00000    90.00000
121  0  .0 PLATFORM ALINE       148.8  -5.4  108.2     .0   -.0    .0 299.5 331.5 275.9  236.3 313.6        .0 270.0 B
 93.21700
122  0  .0 BEGIN SLEEP PERIOD 153.2 -21.8  -32.2  180.0 300.1 180.1 299.5 331.5 275.9  236.3 313.6  359.9  30.1
 93.46051
130  0  .0 END SLEEP PERIOD     148.6  -4.6  -28.5     .2 359.3   1.3 299.5 331.5 275.9  236.2 313.9   62.5 271.5
 93.39197
132 54  .0 TDRS 41W             149.9 -15.4  -94.2     .0    .0    .0 272.0 335.8 286.6  223.1 331.8        .0 270.0           14.0  27.2
 93.39197
132 54  .0 TDRS 171W            149.9 -15.4  -94.2     .0    .0    .0 272.0 335.8 286.6  223.1 331.8        .0 270.0          208.7   3.6
 93.46289
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